LRO Diviner Lunar Radiometer Global Data Products

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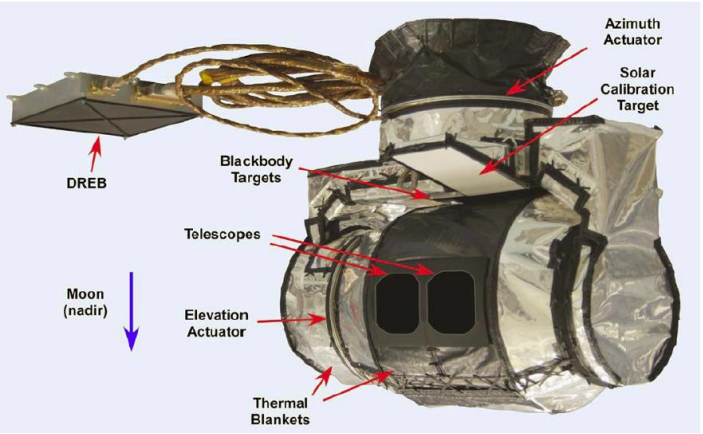
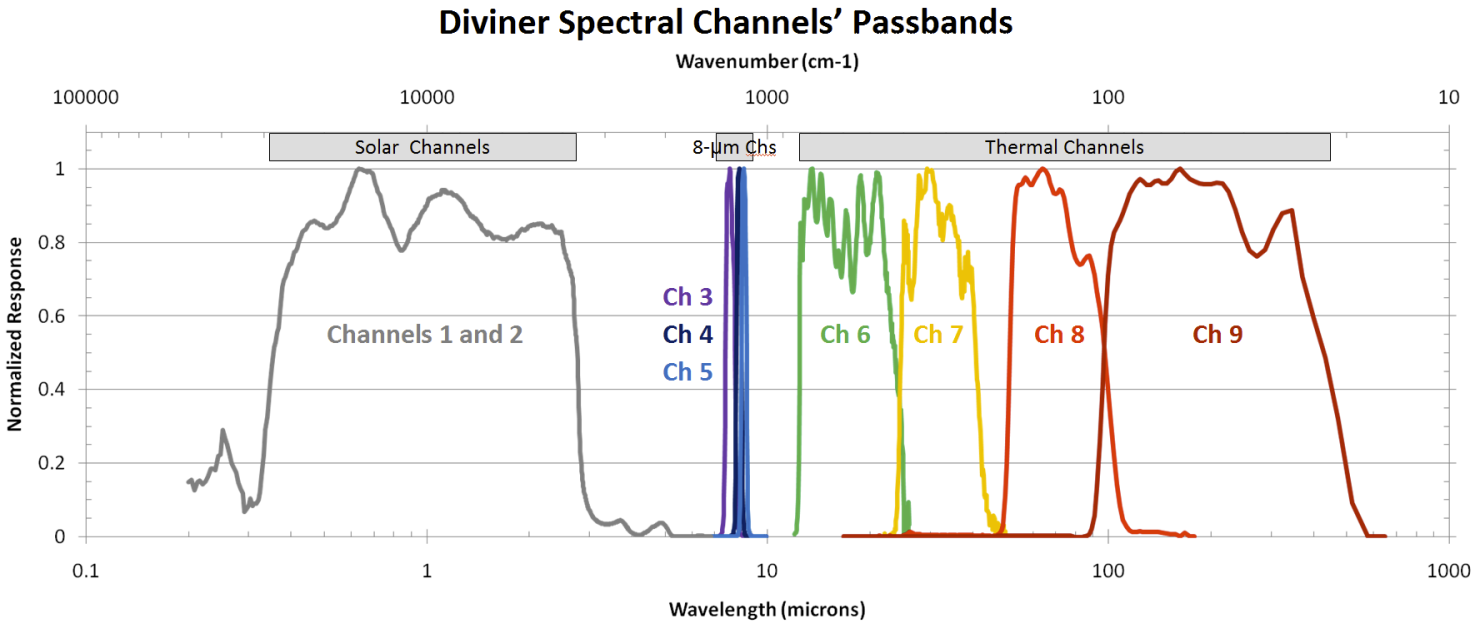
Diviner Lunar Radiometer Experiment

- Solar reflectance and mid-infrared radiance.
- Operating continuously since July of 2009.
- Corner Stone Mission
- Nine spectral channels





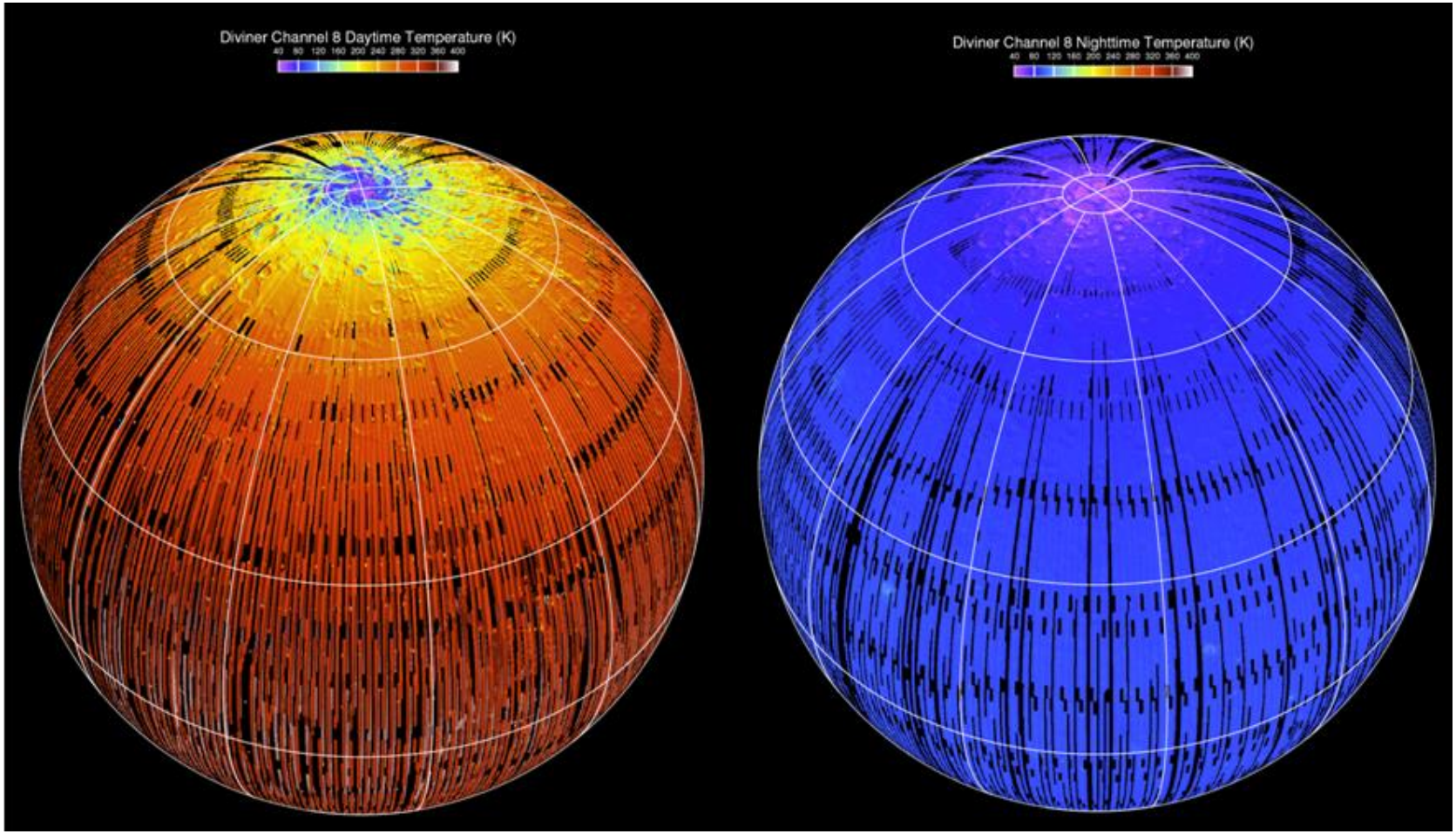
Overview

- Diviner Data products available on PDS
  - Describe products available to community
  - Existing data products have been updated, and new global map products have been added to PDS in 2017.
  - Goal: make the data more accessible and user friendly
- Preview new polar map products in the works

Data Currently on PDS

- RDR – Reduced Data Record (*Level 1*)
  - Archived every 3-months
  - 21 measurements in each channel every 0.128 s
  - Each of these measurements generates an RDR record.
  - Calibrated radiances and associated ephemeris and geometry information.
  - Files contain 10-minutes of time sequenced data.

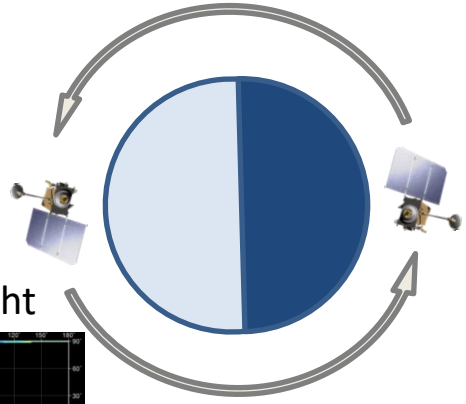
Initial Data Split Day/Night



Data Currently on PDS

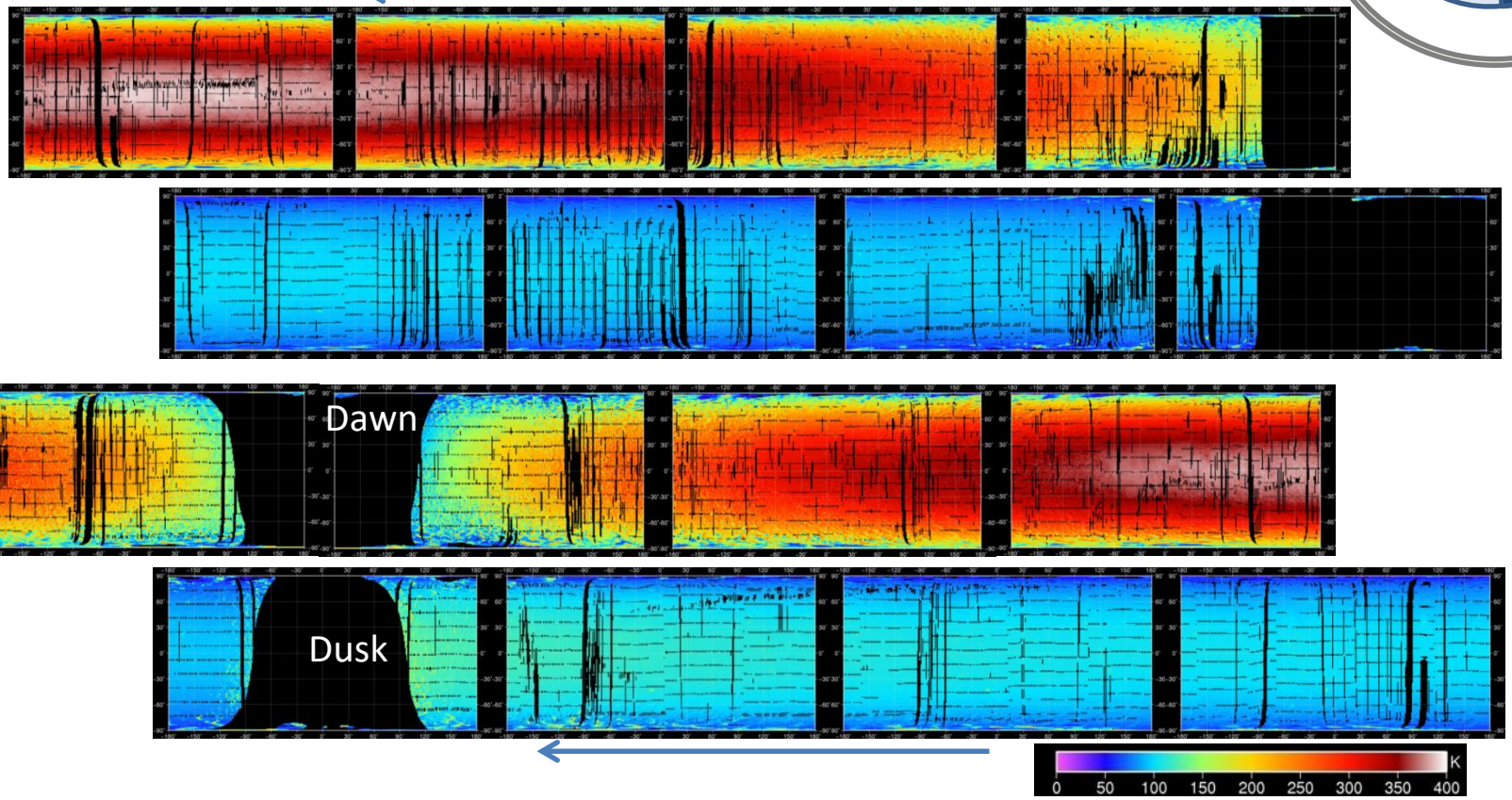
- GDR - Gridded Data Records (*Level 2*)
  - RDR data gridded into global maps of daytime and nighttime visual brightness (Ch 1 and 2) and brightness temperatures (Ch 3-9)
  - Next delivery includes ESM2 (up to 2016)
    - Special thanks to *Raymond Espiritu* (APL)
  - Sub-spacecraft longitude cycles between -180° and 180° every ~27 days
  - Sub-spacecraft local time cycles between 0 and 24 hours once every Earth year
  - 24 monthly maps each year, with each map covering roughly 2 hours of local time.
  - Daytime and nighttime observations on alternate hemispheres in a single orbit
    - Two different local times separated by 180° longitude

Orbit plane inclined ~90°
relative to the lunar equator

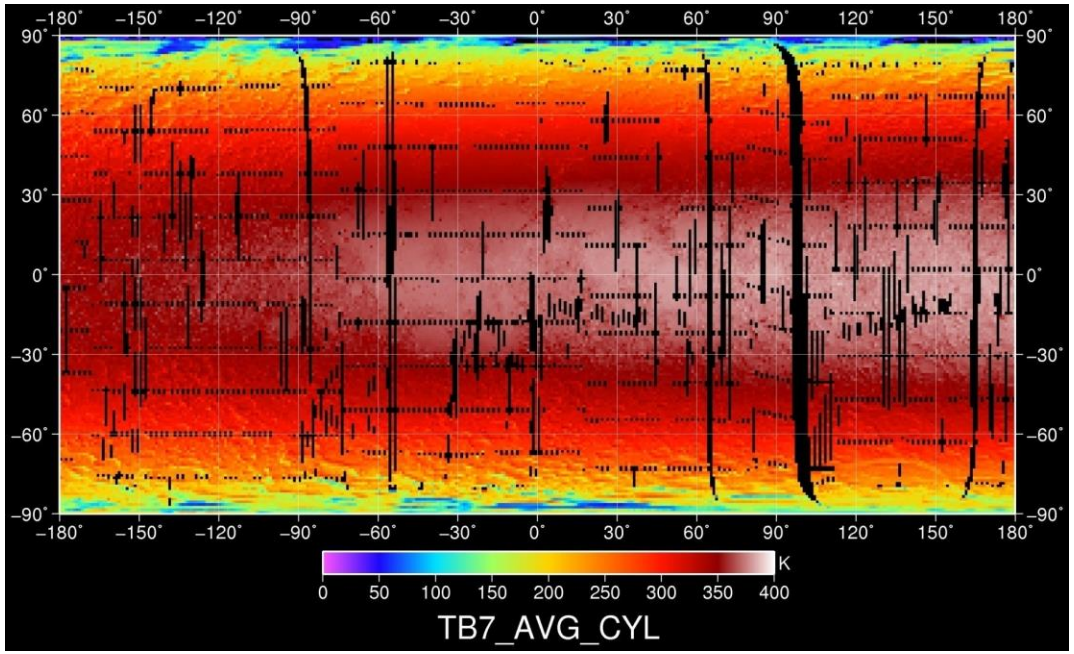


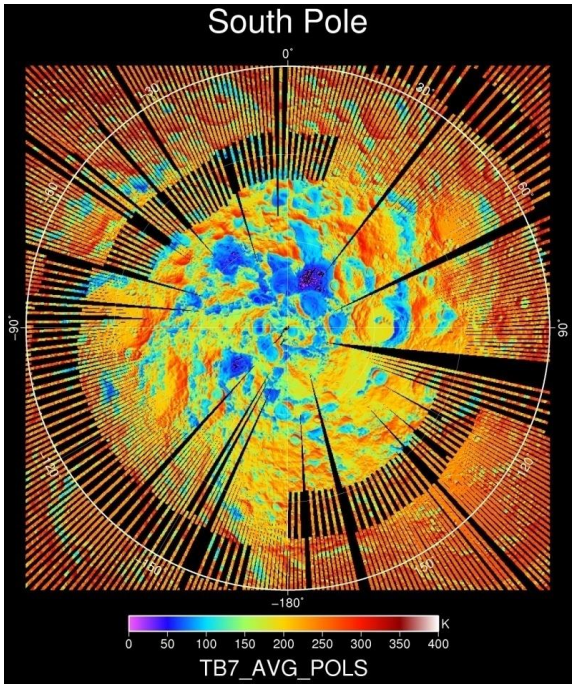
Mission time

First light

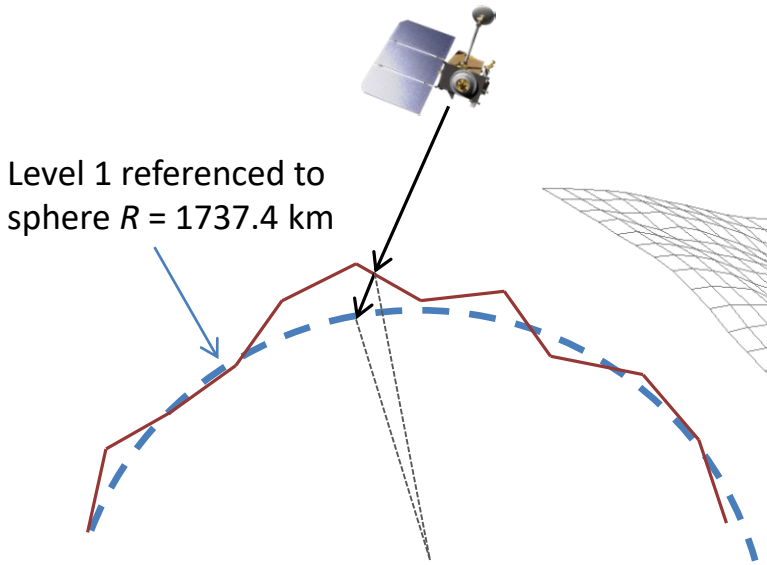


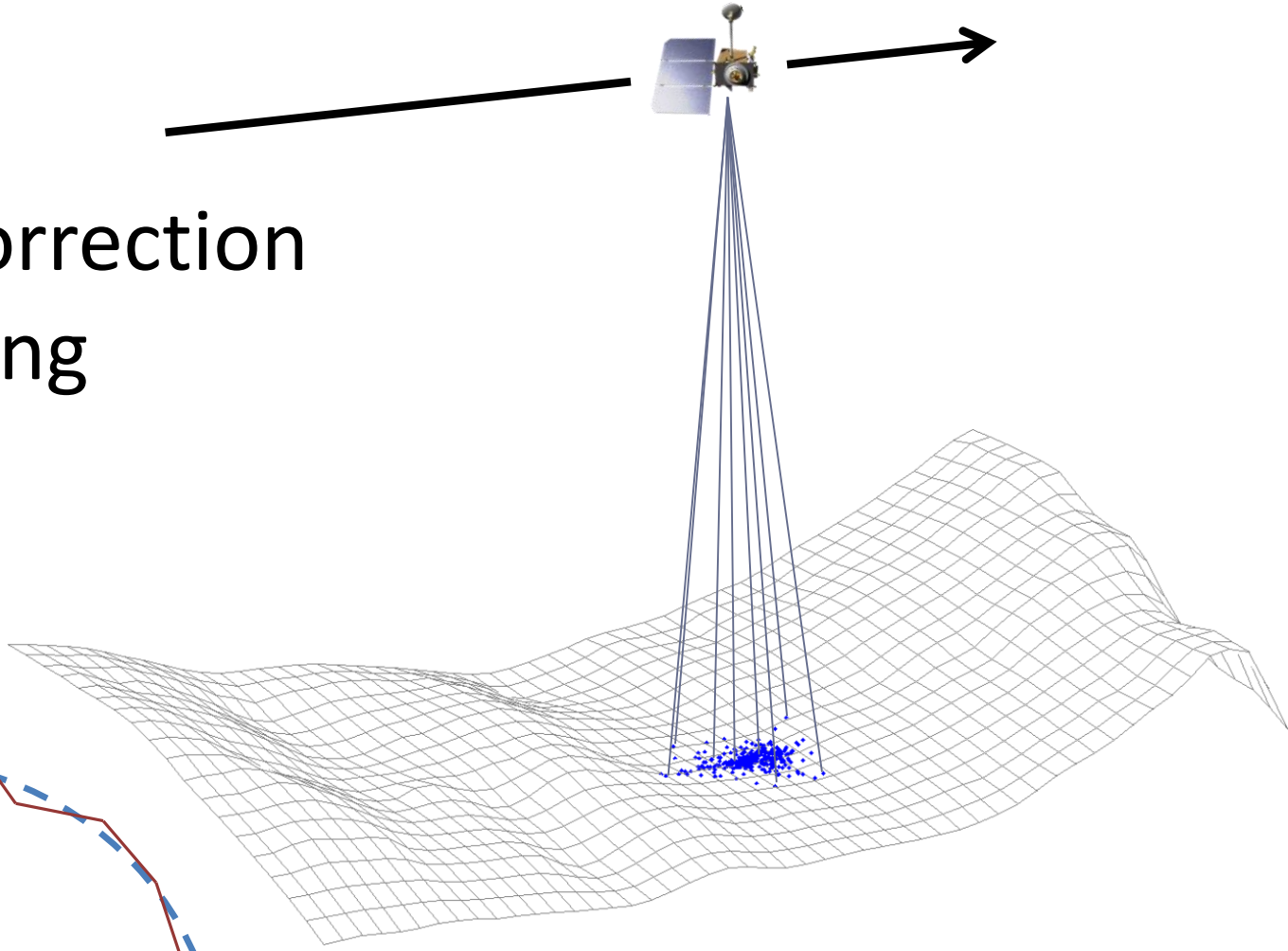
Level 2 (GDR)


−180° −150° −120° −90° −60° −30° 0° 30° 60° 90° 120° 150° 180°
90° 60° 30° 0° −30° −60° −90°
K
0 50 100 150 200 250 300 350 400
TB7_AVG_CYL


South Pole
0°
30°
60°
90°
120°
150°
−180°
−90°
K
0 50 100 150 200 250 300 350 400
TB7_AVG_POLS

Geometric Correction & Binning





- The EFOV is populated with points using the Monte Carlo method (*n* = 100).
- Swarm of points projected onto the surface of the Moon (DEM).
- Modeled points are assigned the same radiance value as the original observation and are used as input to a binning routine.
- See *Williams et al.* (2016) for details.

What Does this Accomplish?

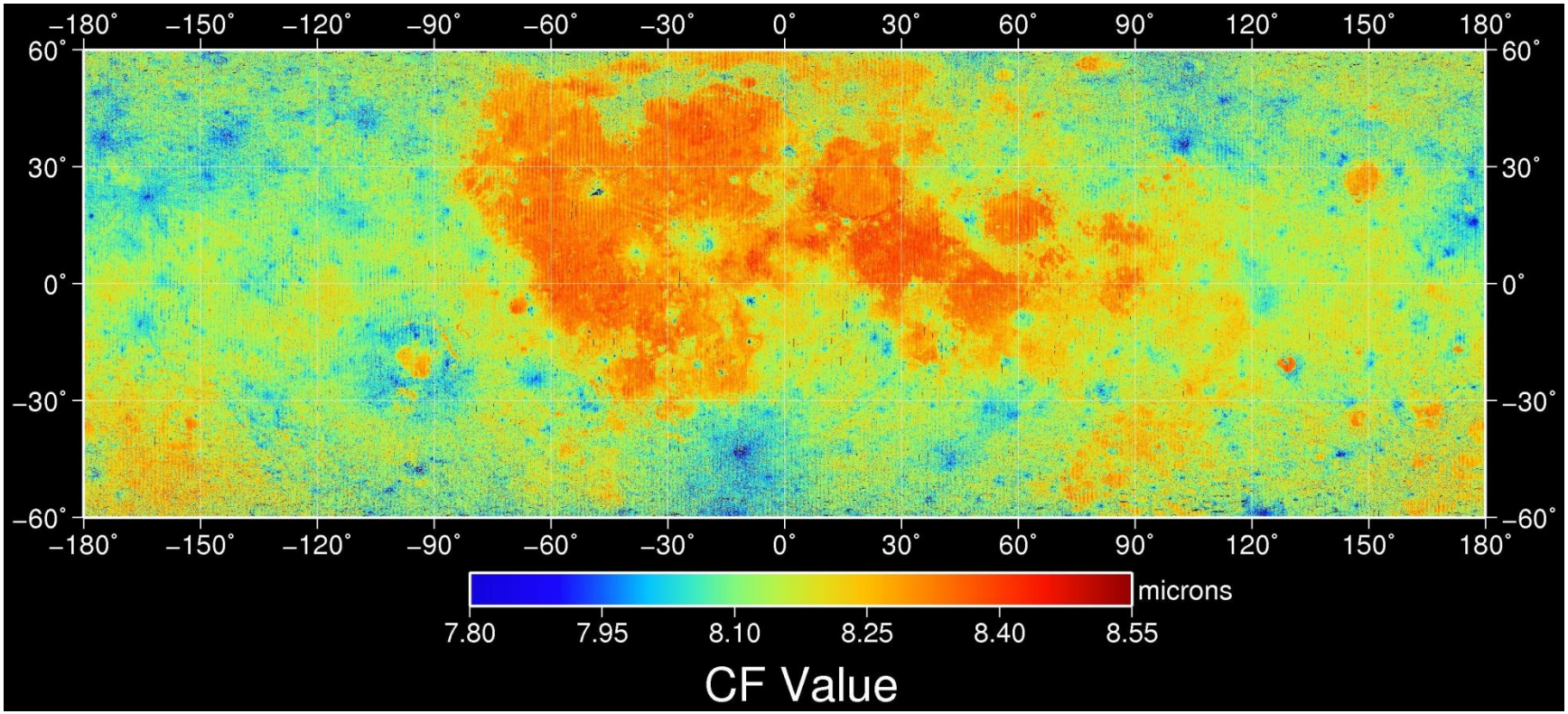
1) Assuming a sufficiently high point density, all bins within the EFOV will be populated with a value. This eliminates the occurrence of empty bins.
2) Where adjacent detectors have overlapping EFOVs, points from different observations may reside in the same bins. The resulting radiance value of each bin is therefore the weighted mean of the observations that fall within it.
3) Diviner channels also become better aligned reducing noise in multi-channel data products.

Data Currently on PDS

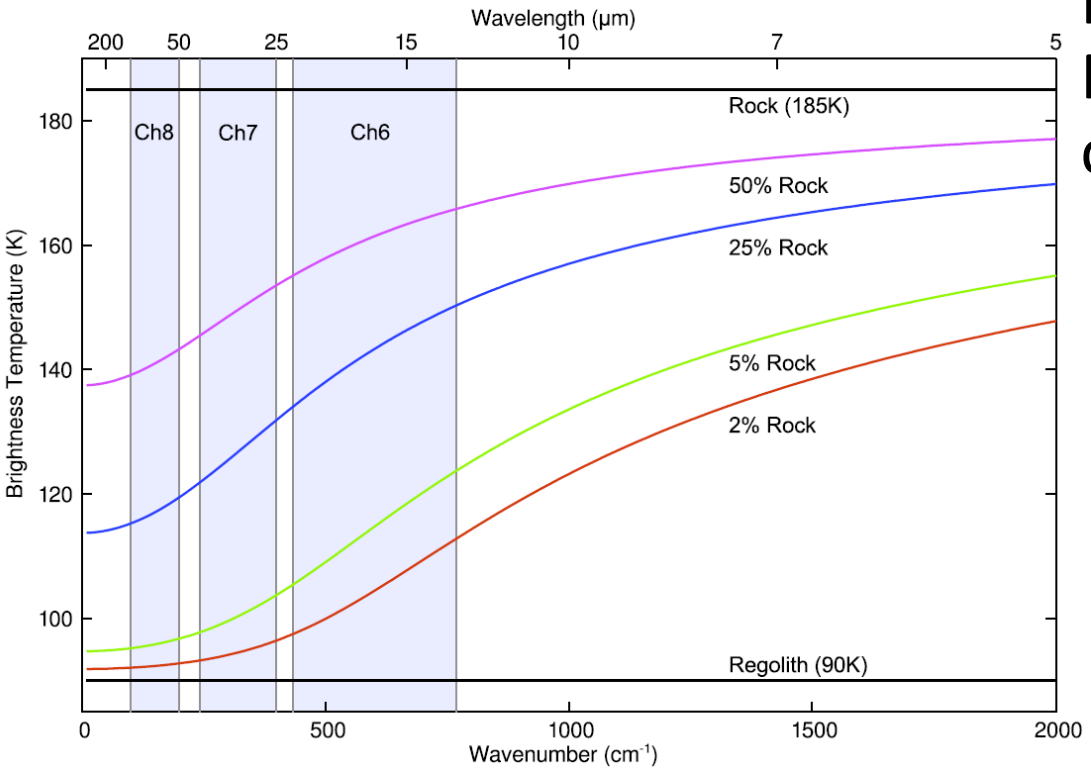
- GDR - Gridded Data Records (*Level 3*)
  - Bolometric Brightness Temperature (Paige et al., 2010)
    - Spectrally integrated flux of infrared radiation from the surface
    - Map cycles and resolution mirror level 2 brightness temperature maps
  - Christiansen Feature (CF) (Greenhagen et al., 2010)
    - Wavelength position of CF diagnostic of bulk mineralogy
    - Cumulative Map
  - Rock Abundance (Bandfield et al., 2011)
    - Cumulative Map
  - Regolith Temperature (Bandfield et al., 2011)
    - Cumulative Map

Level 3 Products

- New standard CF product including ESM1 has been produced
  - Will be updated following completion of ESM2 level 2s



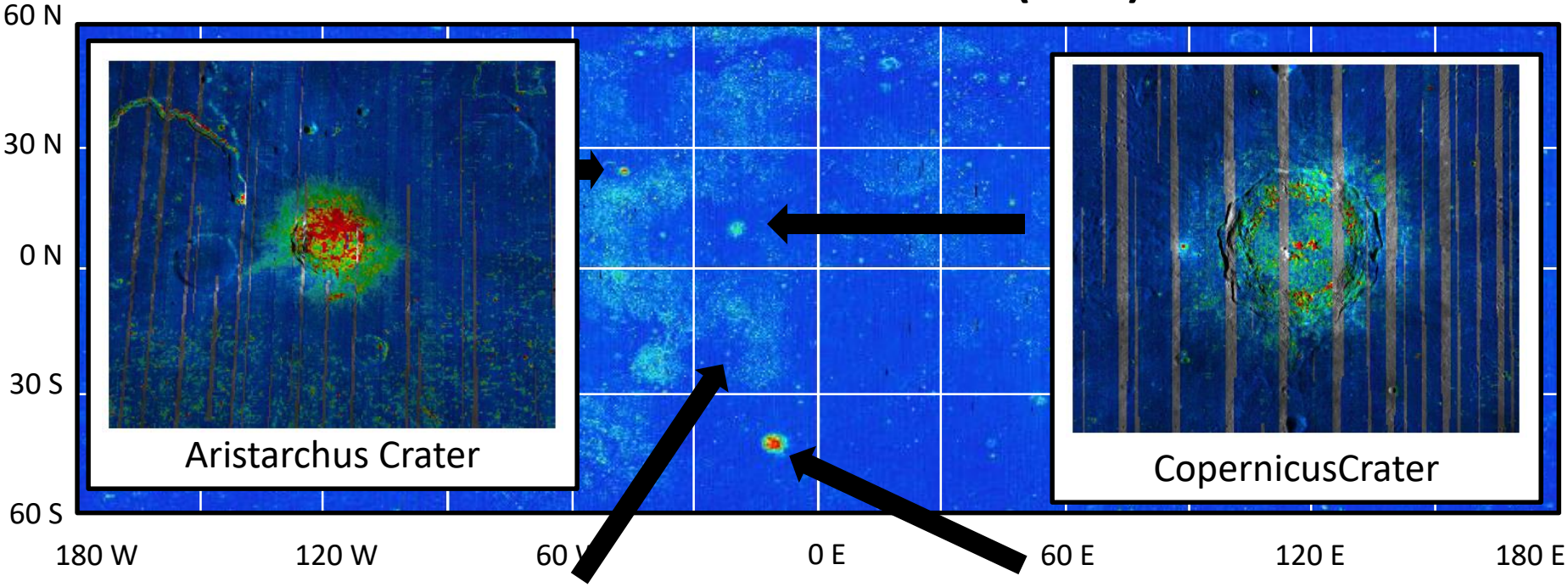
Anisothermality

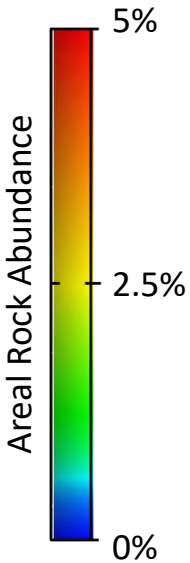


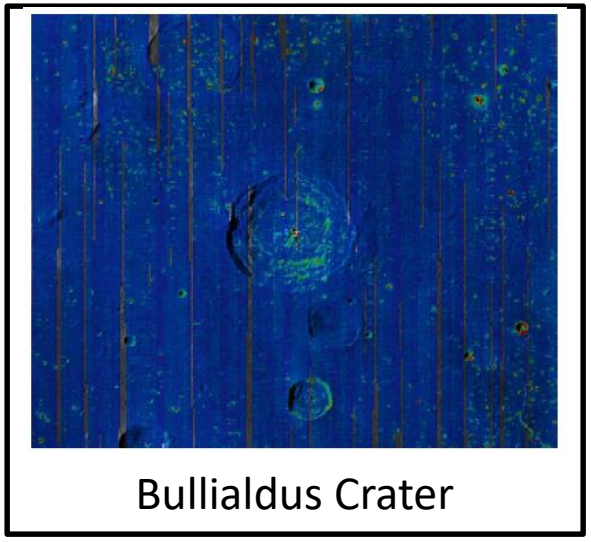
Multiple temperatures in FOV: derived T_b in each channel differs.

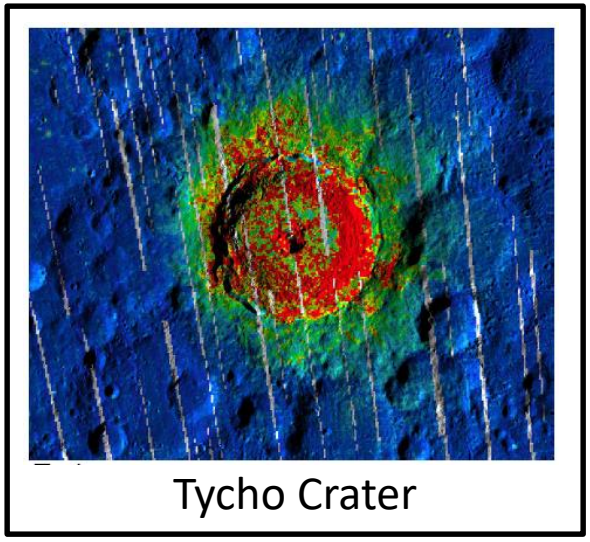
- Warmer temperatures have an increased proportional influence on T_b at shorter wavelengths
- Non-linear nature of Plank radiance with respect to wavelength
- Model as a rock/regolith mixture (Bandfield et al., *JGR*, 2011)

Rock Abundance (RA)







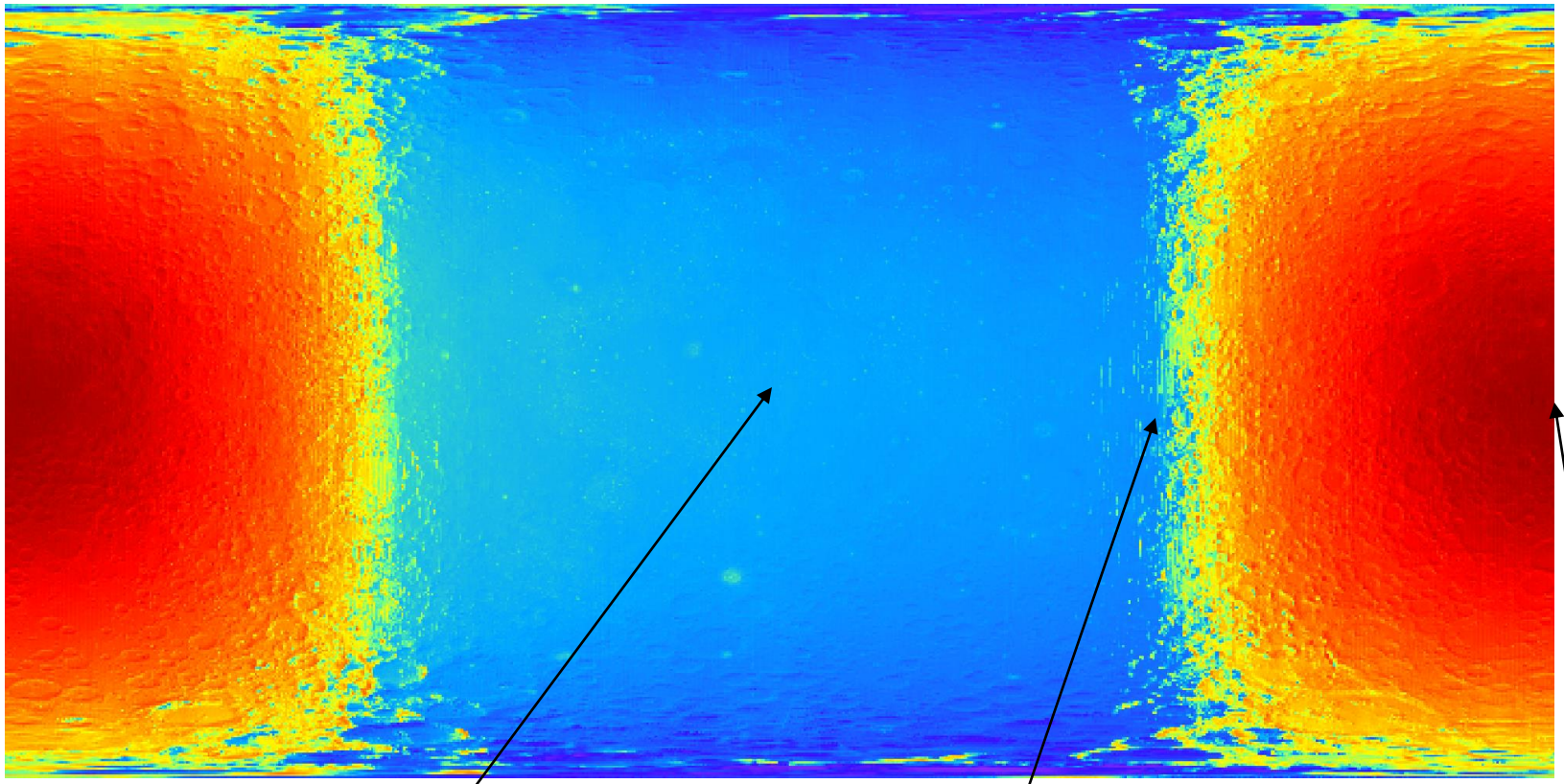


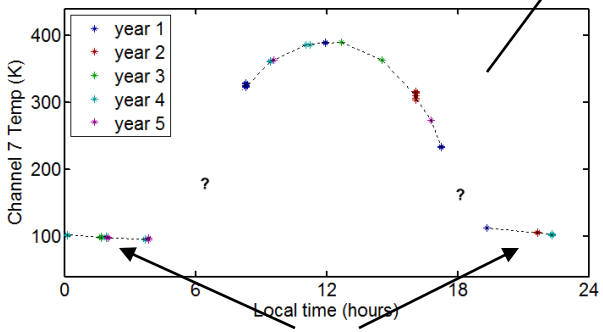
New rock abundance product will be produced after ESM2 level 2s are complete

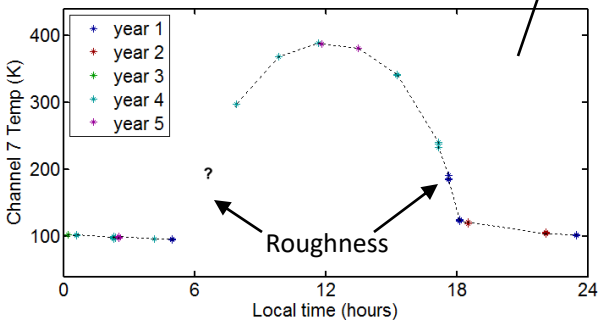
Data Currently on PDS

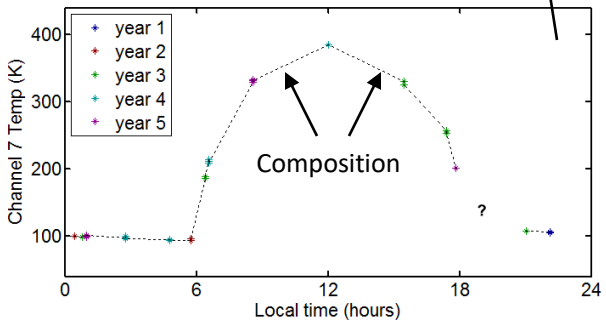
- GCP – Global Cumulative Product (*Level 4*)
  - All nadir-pointing IR data from first 5.5 years of mission
  - ~250 Billion calibrated radiance measurement
  - Compiled into a 0.5 degree lat/lon grid and 0.25 hours of local time
  - Ascii files split into 10 degree latitude bands
  - Diurnal temperatures for each map pixel
  - Significantly lowers the level of effort for data users to incorporate Diviner results into their research or presentations.

Diviner Global Bolometric Temperatures



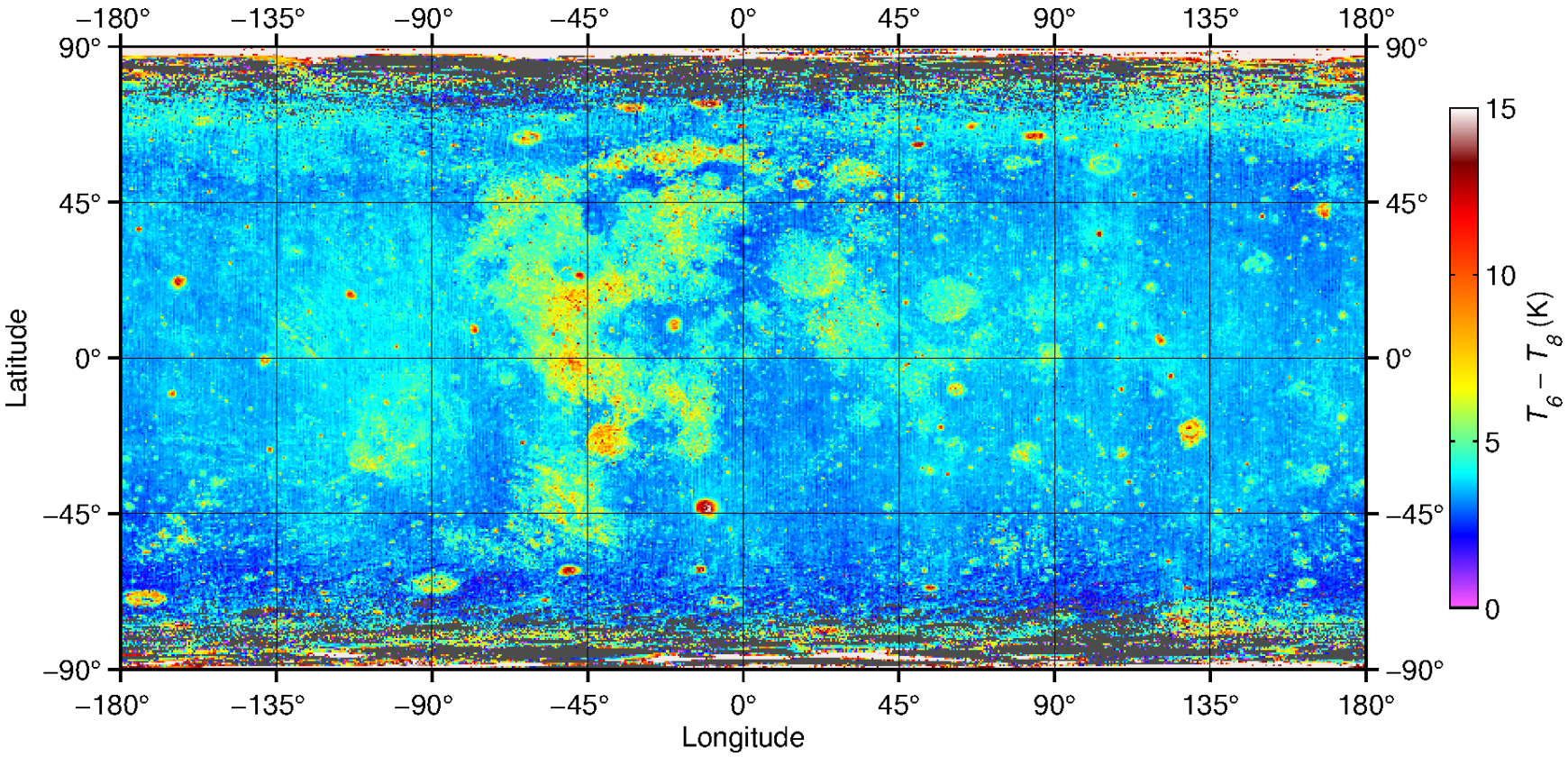






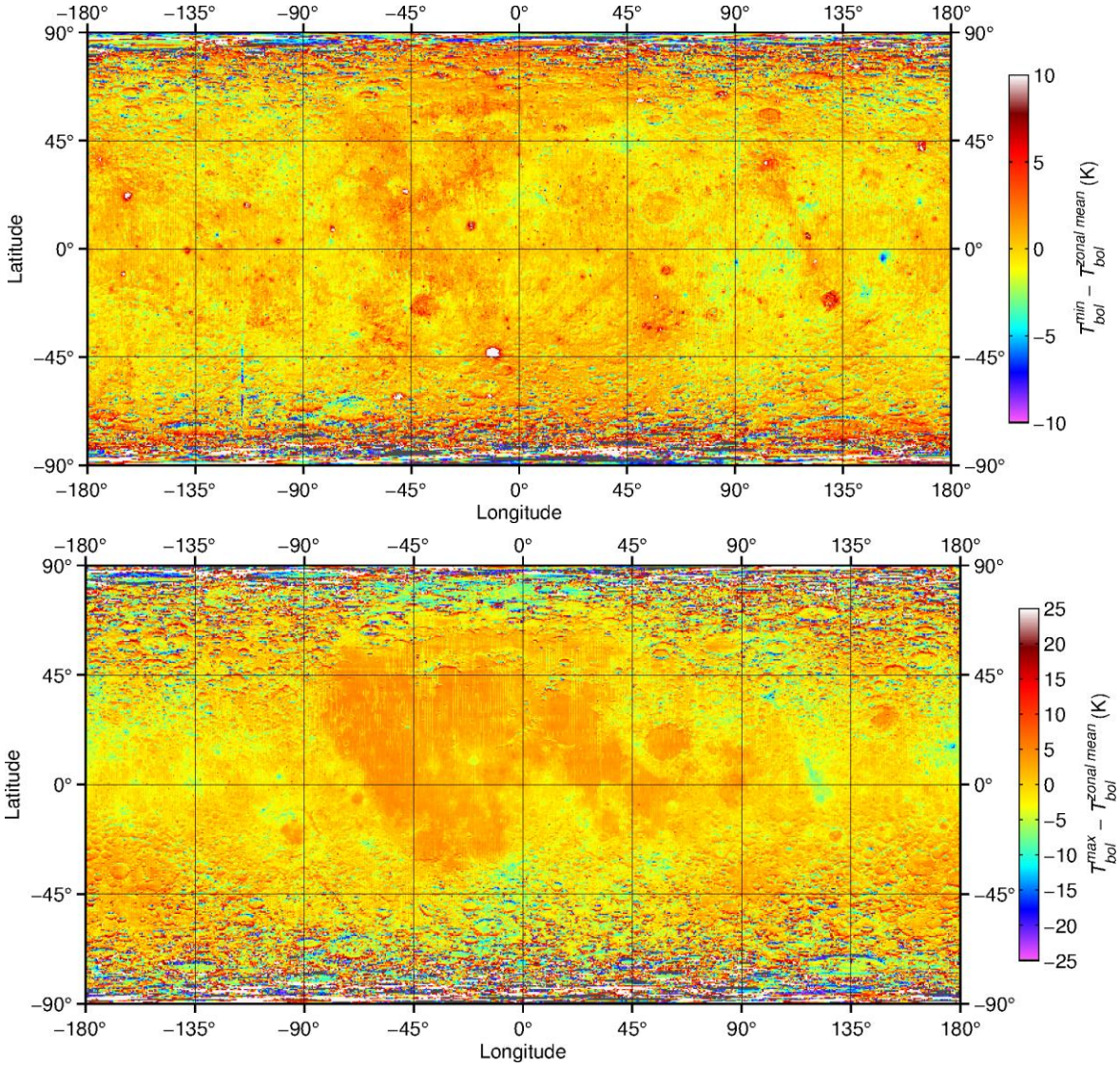
Rocks, Regolith Thermophysical Properties and Vertical Structure

Global Temperature Differences (Ch. 6 – 8)

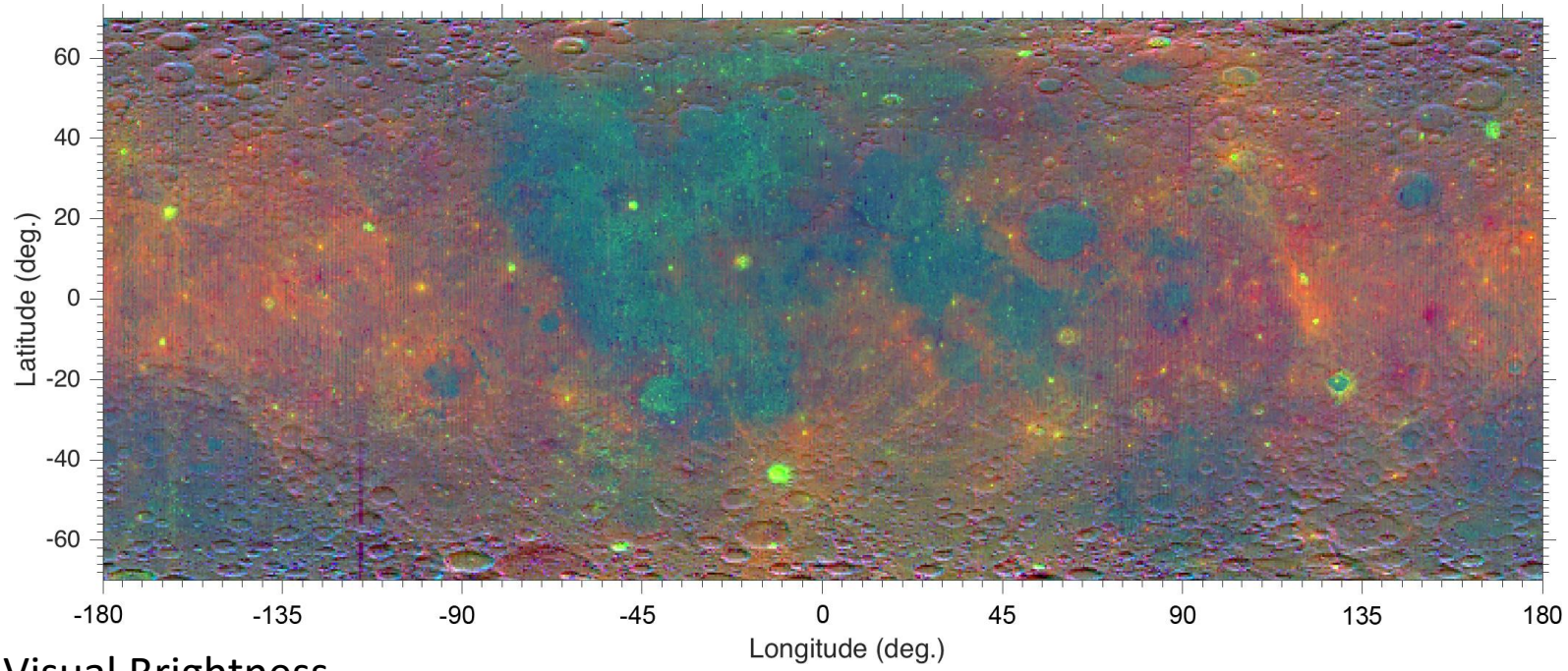


- Highlights variations in regolith thermophysical properties within the top ~30 cm
- High T_6–T_8 = locations where temperature contrasts occur within Diviner's FOV
- Bombardment of the lunar surface that has pulverized material into fine grains, however differences in the bulk properties of the near-surface do persist.

Min/Max Temperatures



RGB Composite Map



Red: Visual Brightness

Green: T_{min} anomaly

Blue: T_{max} anomaly

Features	Colors	Characteristic
Young crater and Rays	Yellow/Orange	Bright, High-TI
Cold spots, radar dark halos	Magenta	Bright, Low-TI
Mare	Cyan/Blue	Dark, High-TI
Pyroclastic deposits	Blue	Dark, Low-TI

More Information

- Diviner Instrument
  - Paige et al. (2010) *Space Sci. Rev.*, 250
- Level 2 data
  - Williams et al. (2016) *Icarus*, 273
- Bolometric Temperature
  - Paige et al. (2010) *Science*, 330
- CF position (mineralogy)
  - Greenhagen et al. (2010) *Science*, 329
- Rock Abundance
  - Bandfield et al. (2011) *JGR*, 116
- Regolith Temperature
  - Bandfield et al. (2011) *JGR*, 116
- Global Cumulative Products
  - Williams et al. (2017) *Icarus*, 283

Future Data Product